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AUTHOR Glas, Gregorio Oscar; Denazis, Julia; Speltini, Cristina
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ABSTRACT

This study sets out the institutional educational project for undergraduate students. At the same time, the authors have tried to adapt the current study programs to the extraordinary scientific and technological development in the second half of the 20th century. The paper tries to integrate various sources. Written documents and the structure of the Undergraduate Curriculum of Universities in some European countries have also included the opinions given by graduates, professors and professional people related to engineering. The authors have chosen different points to be taken into account through the analysis of the Undergraduate Curriculum. These points comprise the following: length of the engineering studies courses, credit-designed curriculum and the criteria to assign those credits, cycle division, distribution of subjects and akin activities in the Curricular Structure, Thesis in Engineering, the responsibility of connecting the student to the social situation, and the characteristics of their degrees and teaching methods. All these points have been taken into account to make a proposal to adapt the current syllabus to the social demands and production challenges. The conclusions of the paper are a synthesis of the different perspectives and the authors' views, which are not only open-ended but also try to foster an unpostponable debate about the teaching of engineering in a complex and changing world. (Contains 11 references.) (SAH)

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Engineering Education from The Standpoint Of Curricular Structure And The Challenges Of The End Of The Century

Glas, Gregorio Oscar; Denazis, Julia and Speltini, Cristina
Faculty of Engineering
University of Buenos Aires.
Av. Paseo Colon 850 - 1063 Buenos Aires - Argentina

Abstract -*In this study, we set out the institutional educational project for our undergraduate students. At the same time, we have tried to adapt the current study programmes to the extraordinary scientific and technological development in the second half of the XXth. century.*

Our paper tries to integrate various sources. Written documents, the structure of the Undergraduate Curriculum of Universities in some European countrie and we have also included the opinions given by graduates, professors and professional people related to Engineering.

We have chosen different points to be taken into account through the analysis of the Undergraduate Curriculum. These point comprise the following: length of the engineering studies courses, credit-designed curriculum[1] and the criteria to assign those credits, cycle division, distribution of subjects and akin activities in the Curricular Structure, Thesis in Engineering, the responsibility of connecting the student to the social situation, the characteristics of their degrees and teaching methods.

All these points have been taken into account to make a proposal to adapt the current syllabus to the social demands and production challenges.

The conclusions of the paper are a synthesis of the different perspectives and our views, which are not only open-ended but also try to foster an unpostponable debate about the teaching of Engineering in a complex and changing world.

Introduction

The vertiginous scientific and technological developments in the second half of the XXth. century make us think over Engineering Education and its association with the social demands. We believe it is very important, to pay attention to the factors which have influenced the increase of the demands over the Engineering formation.

Among the main factors, we can mention the opening of the economy and the transference of foreign capitals to productive areas in the Country.

These factors force to Engineers to respond intelligently to unknown situations and go beyond established knowledge to create unique interpretations and outcomes.

As a result, we have analysed the current Curricular Structure of the School of Engineering at the University of Buenos Aires (UBA) and have made up an agenda with the main items to be taken into account in order to make a proposal of change.

Methodology Adopted In This Work

This work is oriented to understand the special characteristics of this School of Engineering as a result of the observation of concrete situations and meetings where main issues related to the curricular structures were discussed. Our objective is to study the institutional context of the School of Engineering. The execution of this work was oriented to make possible the integration of different sources: Written Papers; different opinions from members of the academic community and graduates. Among the Written Papers, we have taken into account the "Encuadre General de los Planes de Estudio de las Carreras de Ingenieria[2]", the " Government Agreement for the Reform of the University of Buenos Aires" and the "Curricular Structure of Universities of some European Countries". The conclusions show the contrast between the perspectives of the groups involved and our interpretations, which attempt to support the debate encouraging autonomous thought.

Although we took each item separately because of methodological reasons, they are narrowly related and we will come back again over some aspects in our analysis.

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[1] Curriculum: we take it not as a simple description of the academic study programmes but a practical problem which allows us to have a guideline for the action. This includes not only the syllabus but also cognitive strategies, attitudes, values, habits and all kind of skills.

[2] This document contains the general orientation for the syllabus of the Engineering careers and constitutes the frame of reference in which the Curricular structure is developed, in force in this School of Engineering since 1986.

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Guideline Selected By Our Analysis. Items in the agenda

For our analysis, we took into account the following items: Entry conditions; Length of the Engineering courses of study; Curricular Structure by credits; Cycle division; Distribution of subjects and akin activities in the Curricular Structure; Engineering Thesis; Compulsary social work. Apprenticeship; Equivalence of the Engineering degree of the University of Buenos Aires in an International context; Curricular Contents; ways of teaching and learning.

Entry conditions

Present situation: The first stage in the University of Buenos Aires is the Ciclo Básico Común[3]. It lasts for one year and the student must pass 6 subjects. Four of them are related to the Engineering studies. The other two are common to all the careers in the University of Buenos Aires.

Problems: It is very difficult to integrate the CBC subjects with the subjects taught in the School of Engineering because the first ones are designed and delivered by the University of Buenos Aires. This segmentation limits the academic decisions taken by the School of Engineering during that first year.

Proposal: We propose a "Levelling programme" directed to the students who will enter the University of Buenos Aires. The main purpose of this programme will be to promote the students' interest and provide knowledge and abilities to start University studies. This programme will consist of distance or conventional learning and it will be optional. To carry it out, it will be necessary to have completed the secondary studies or to be taking the subjects corresponding to the last year in that level.

Length of the Engineering Courses of Studies

Present situation: The graduate degree is obtained by successful completion of 4.340 hours teaching distributed in 12 semesters (C.B.C. is not included here). It lasts nominally 6 years, but actually 8 years.

Problems: The excessive duration of the Engineering careers was a fundamental issue under discussion and there was unanimous agreement on the necessity of reducing it, so as to facilitate the graduates their early insertion in the professional field.

This problem can be seen by analysing the syllabus of the Engineering careers and we attribute this to the thematic superposition among different subjects developed in the Curriculum and the addition of themes without a global vision of the syllabus.

Proposal: We propose in order to get the engineering degree, to complete a total of 3.840 teaching hours, divided into two cycles.

These hours will be distributed in two semesters of 16 weeks each, made up of 24 teaching hours a week with compulsory attendance. This means that Undergraduate Engineering Careers will last five years divided in two cycles. According to the convention in use in Continental Europe "Long career" means the University Studies up to five years, generally divided in cycles of two or three years. This is the reason why the Engineering degrees given by the Argentine Universities, will be considered to a "Long Career".

Some of the actions for the implementation of this proposal are:

A) To integrate the contents of the subjects from a global vision of the syllabus, leaving out thematic superposition among different subjects developed in this School.

B) To reduce the number of subjects by amalgamating courses, distributing themes so that subjects are of a higher density,

C) To eliminate themes in undergraduate courses which not being relevant to the student's formation, can be integrated in any other optional subject or left for a future specialisation,

D) To emphasise the implementation of monthly or bimonthly courses of less duration.

E) Change some teaching strategies based on transmitting knowledge for other strategies based on developing scientific-technological competence.[4]

Curricular structure by credits

Present situation: The academic year is divided into two semesters and this School operates Credit Accumulation System.

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[3] Ciclo Básico Común (CBC): Academic programme, common to all Schools in the Univerity of Buenos Aires comprising the first year in every career.

[4] We refer to the intricate capacities; built up from integration of previous knowledge; which allows to give an answer to any different, variable and unpredictable situations To develop scientific-technological competence means to educate persons able to handle instruments, devices, operative systems, different strategies in order to evaluate performances, as well as, social and cultural pertinence.

The content covered by each syllabus is grouped into compulsory or optional subjects. Each of them has been assigned a determined number of credits.

The current assignation of credits is equivalent to the number of hours attending the classes. For example: if a student has a subject with a 24 hour a week compulsory attendance, he will obtain 24 credits. That is to say: a credit for hour of attendance.

Problems: The current system of credit assignation, equivalent to the number of hours attending classes, does not show the real effort made by the student in order to pass the subject.

This model has also severe limitations and disadvantages because it neither contemplates strategies related to the construction of knowledge nor evaluates the rapid change of post-industrial society.

Proposal: Our proposal is to replace the old way of credit assignation by one which involves learning processes. That is, to take into account the attendance to teaching hours, the estimated home study time, the time used in simulation practise, resolution of problems, etc.

As a general rule, we propose that the Undergraduate Engineering careers will be based on subjects and kindred activities which will award the students 240 credits: this equals to an average of 24 credits per semester, with a total of 10 semesters. That is to say that a semester in which students pass every corresponding subjects, will equal to an assistance of 384 hours and 24 credits will be awarded.

Distribution in cycles

Present situation: The Engineering careers, last six years. The first year is the CBC and it is followed by five years of scientific and technical studies, which leads directly to professional life.

Problems: The CBC is a requisite to undertake university studies and, as we have mentioned earlier, there is not enough integration between these first- year-subjects (C.B.C.) and the following ones.

Also, the current syllabus of the Engineering careers does not contemplate intermediate certifications, which is not compatible with challenges nowadays.

Proposal: We propose for the Engineering careers the division in two-grade cycles [5]. The first one comprises 4 semesters, of 16 weeks each, including 24 hours a week compulsory attendance to teaching classes.

The completion of the first cycle leads to the Diploma of General University Studies, and the end of the second cycle leads to the Engineering degree in the corresponding specialisation. Implementing the Levelling Programme and the necessary changes in the Curricular Structure in cycles, the CBC will be replaced.

FIRST CYCLE: in this cycle, all the required elements for the revision or affirmation of the chosen career will be met and also the Basic Scientific and Technological formation, which constitutes the basis of ulterior learning. The subjects included in this cycle are considered a necessary basis for the remainder of the syllabus.

This cycle gives the access and prepares students for the pursuit of study in the second cycle. It comprises 1.536 teaching hours divided in 4 semesters of sixteen weeks, including 24 hours a week compulsory attendence to teaching classes; granting a total of 96 credits approximately. This includes a foreign language teaching, especially English.

SECOND CYCLE: this second cycle will give the students a total of 144 credits, equivalent to 6 semesters of 2.300 teaching hours distributed in the different subjects which will prepare students for the exercise of professional responsibilities. Within this second cycle, the students will have a high percentage of credits in optional subjects and academic activities which will come the requirements for a "Learning Activity". These requirements will be selected by the Permanent Curricular Commission of the Career[6]. The subjects will be given in our School as well as in any other School of the University of Buenos Aires. The academic activities may give credits according to the criteria of the Curricular Commission and may be performed in the School or in any other School or enterprise. For a better insertion in the professional field, the student should accomplish a compulsory social work which will be implemented as apprenticeship, rented or not according to the possibilities of our scientific and productive situation. The elaboration of an Engineering Thesis, as a culmination of their undergraduate studies, will be required as a main issue for their methodological formation. The social work and the Thesis are essential for the Engineering's global formation; for this reason they are compulsory. Including social work helps the student to combine course learning with work experience and it is an opportunity to gain more experience as part of their training. At the end of this cycle the student will receive the grade degree of Engineer oriented to the specific specialisation together with a certificate mentioning the characteristic of the Thesis completed.

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[5] We understand by the word "CYCLE" a stage with an own purpose, which represents the access to a superior stage. That is to say it contents the necessary preparation base of the ulterior formation of the following cycle.

[6] This Commission (one for each career) is made up of teachers, graduates and undergraduates. Its function is to propose changes and modifications to syllabuses.

Distribution of Subjects and Related Activities Contemplated in the Curricular Structure

Present situation: The current Curricular Structure has a flexible nature with three kinds of subjects: compulsory, optional and other academic activities.

Problems: These three groups of subjects take into account neither the integration between the social work and University studies nor the methodological formation which provides the making of the Thesis in Engineering .

Proposal: The curricular structure will contemplate five groups of "Learning units" or any other academic activities which may give credits to the students.

A) First group: compulsory subjects, which constitute the core of the formation according to the profile of the future graduate. Those are the trunk subject areas that constitute the subjects without which other learning cannot take place effectively. In this group, essential subjects such as Basic Scientific Formation, Basic Technology, and Applied Technology are included, as well as a foreign language. They will award about fifty percent (50 %) of the total credits of the career, approximately one hundred and twenty four credits.

B) Second group: compulsory subjects corresponding to the orientation the students choose to make the engineering thesis. They will be compulsory and constitute the core of the orientation. These subjects will be studied in the Engineering Faculty of the University of Buenos Aires. They will award about fifteen percent (15 %) of the total credits of the career, approximately thirty-six credits.

C) Third group: optional subjects assembled in different areas according to the speciality and the apprenticeship with an compulsory character are a part of the future of the undergraduate formation. These subjects will give the students the essential complementary formation. In those groups of subjects may have courses, which may be studied and approved by other Schools of the University of Buenos Aires. The Permanent Curricular Commission for each career will establish the rules for the election of the subject in this third group according to the orientation that the student choose to carry out the Engineering Thesis. The apprenticeship will be considered within this group and the students may select subjects according to the available offers, granting a number of six to ten credits. The Curricular Commission of the corresponding career will establish the number of credits as regards the type, intensity, duration and importance of the work fulfilled. The subjects and the apprenticeship will grant a minimum of twenty-two and a half percent (22,5 %) of the total credits of the career. That is to say, fifty credits.

D) Fourth group: it includes optional subjects that students may choose freely. These optional subjects may award credits according to the guidelines of the Permanent Curricular Commission for the career. The subjects and activities of this fourth group may grant up to the fifty percent of the total credits of the career, equivalent to twelve credits.

E) Fifth group: this group is restricted to the Engineering Thesis which will award the seven and a half percent (7,5 %) of the total credits of the career, that is to say eighteen credits.

Engineering Thesis

Present situation: At present it has an optional character.

Problems: This optional character of the Thesis causes only those students (actually a few of them) who choose to do it, to have the possibility of facing the challenge to integrate the knowledge obtained throughout their studies and apply them on a searching work related to the methodology of Engineering.

Proposal: its making must be compulsory as the final work is in the University careers of Continental Europe and the "Master Thesis" in the majority of the Anglo- Saxon universities. The thesis is a work which may adopt a character of researching technological development and integration of the specific knowledge reached by the students during their formation. Since the name of Thesis of Grade is a nomenclature not frequently used in our country, it is convenient to emphasise its definition. For instance, the University of Stantford in the United States of America (U.S.A.), defines the thesis of master like this: "The thesis is generally a long written essay about a theory put forward and supported by arguments". The Thesis of grade for Engineer does not demand an original contribution to the knowledge, as it is expressed in the thesis of doctorate.

Obligatory social work. Apprenticeship

Present situation: The social work is not considered in the current syllabus.

Proposal: This work is based on the necessity of articulating the theoretical-practical formation with experiences of supervised works and professional practises in situations out of the university field. The integration of the curricular structure, the practice of a social service in order to link the theory with the practice, so as to develop social solidarity attitudes. Our proposal is to establish an obligatory external apprenticeship for all the students who belong to the Engineering career. A certain number of credits will be granted, to be set by the Permanent Curricular Commission of the careers within the previously established rules.

Equivalence of the engineering degree of the University of Buenos Aires in an international context

Engineering studies in the Argentine Republic have their origin in the system followed by most of European Universities, awarding an engineering degree, which corresponds, to a "Long Career". We understand that this system should not be modified, but should guarantee the quality of formation so that the engineering degree may be recognised by the "International Scale", with the level of Master of the Anglo-Saxon Universities. With the inclusion of an compulsory Engineering Thesis, as the culmination of the grade career, the quality in the engineering formation necessary for the recognition of the grade degree in the international context is completed, as much in the academic order as in the professional practice.

Curricular Contents, Ways of Teaching and Learning

Present situation: The didactic activity is usually organised in courses of separate theoretical and practical lessons. The practical ones involve laboratory work or problem resolutions.

Problems: Most of the courses are based on transmitting existing knowledge and are criticised as being too theoretical and for failing to meet the demands of practice.

Proposal: We propose a close theoretical - practical relationship so that both aspects will enrich each other. The methodological decision, which intends to surpass the dichotomy theoretic - practice tries to recognise the integration of both aspect. In this proposal the main point is the construction of knowledge as a methodological structure, the design of activities which promote the starting of cognitive processes in students, stimulating the interpretation, critical judgement and recognition of actual problems in order that the dialogues between students and professors may have significance. We insist on the necessity of integrating to the curricular structure, innovative methodologies according to the technological advances where students are encouraged to participate and lead discussions. By their nature certain courses require theorical-practical sessions, such as work in a laboratory. The School of Engineering may use technological information, for example, using Internet software and include interactive sessions. The permanent use of the simulation by Computer as technique for the prediction and comprehension of systems in which the future Engineer will have to take part, will be considered as normal, so that the student may familiarise from the very beginning with analysis and design processes, which will constitute the fundamental point for their professional formation.

Summary

The proposed modification of the curricular structure for Engineering careers has a main objective: the adaptation to the current necessities and tendencies, improving quality formation and the utilisation of different resourses. In this proposal many aspects of the academic life of the institution are included so as to reach a major efficacy in professional researches, and teacher's formation, through an effective articulation of teaching, researching, extension and transference. For this, the development of an academic moral, reaffirmation of the integrity, coherence, social values and responsibility deserve a particular consideration. In the different sources proposed the necessity of reducing the length of the careers, the number of subjects without deteriorating the basic scientific formation of high quality that the student must receive was considered. For this reason a Curricular Commission, must think about the professional profiles with these new elements of searching for suitable opinions, that will contribute to the creation of new specialities in engineering to be implemented as a second cycle of the grade career. In this way, new disciplines different from the traditional ones, may be designed. Taking into account the search for improving all kinds of resources, we propose to study the curricular adaptation and to perform it through a gradual step-by-step process till most relevant changes are effective.

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